

1                   **SAFE AND AUTOMATIC METHOD FOR REMOVAL**  
2                   **OF COKE FROM A COKE VESSEL**

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4                   FIELD OF THE INVENTION

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6       The present invention relates to the field of hydrocarbon processing and, in  
7       particular, to heavy hydrocarbon processing in coke vessels.

8  
9                   BACKGROUND OF THE INVENTION

10  
11     Many oil refineries recover valuable products from the heavy residual  
12     hydrocarbons (commonly referred to as resid or residuum), which remain  
13     following initial refining, by a thermal cracking process known as delayed  
14     coking. Generally, the delayed coking process involves heating the heavy  
15     hydrocarbon feed from a fractionation unit, then pumping the heated heavy  
16     feed into a large steel vessel commonly known as a coke drum. The  
17     unvaporized portion of the heated heavy feed settles out in the coke vessel  
18     where the combined effect of retention time and temperature causes the  
19     formation of coke. Vapors from the top of the coke vessel, which typically  
20     consist of steam, gas, naphtha and gas oils, are returned to the base of the  
21     fractionation unit for further processing into desired light hydrocarbon  
22     products. The operating conditions of delayed coking can be quite severe.  
23     Normal operating pressures in coke vessels typically range from 25 to about  
24     50 pounds per square inch and the heavy feed input temperature may vary  
25     between 900°F and 950°F. The coke drums operate in pairs, with one drum  
26     feeding residuum and the other drum undergoing the "decoking" sequential  
27     steps. The drums typically operate on a cycle, switching every 12-30 hours.  
28  
29     Coke vessels are typically large, cylindrical vessels commonly 19 to 30 feet in  
30     diameter and two to three times as tall having a top head and a funnel shaped  
31     bottom portion fitted with a bottom head and are usually present in pairs so  
32     that they can be operated alternately. Coke settles out and accumulates in  
33     the vessel until it is filled to a safe margin, at which time the heated feed is

1 switched to the empty "sister" coke vessel. Thus, while one coke vessel is  
2 being filled with heated residual oil, the other vessel is being cooled and  
3 purged of hundreds to thousands of tons of coke formed in the vessel during  
4 the previous recovery cycle. The full vessel is isolated, steamed to remove  
5 hydrocarbon vapors, cooled by filling with water, drained, opened, and the  
6 coke is removed.

7

8 Coke removal, also known as decoking, begins with a quench step in which  
9 steam and then water are introduced into the coke filled vessel to complete  
10 the recovery of volatile, light hydrocarbons and to cool the mass of coke. The  
11 vessel is then vented to atmospheric pressure. Decoking is accomplished at  
12 most plants using a hydraulic system consisting of a drill stem and drill bit that  
13 direct high pressure water jets into the coke bed. To cut coke in this manner  
14 the top and bottom heads of the vessel must be removed. A rotating  
15 combination drill bit, referred to as the cutting tool, is about 18 inches in  
16 diameter with four (4) nozzels and is mounted on the lower end of a long  
17 hollow drill rod about 6 inches in diameter. The drill bit is lowered into the  
18 vessel, on the drill stem, through a flanged opening at the top of the vessel. A  
19 "bore hole" is drilled through the coke using the four nozzles angled  
20 approximately 60 degrees down from horizontal. This creates a hole from  
21 about 3 to 6 feet in diameter for the coke to fall through. There is normally a  
22 naturally occurring small hole in the coke bed for the initial pass because the  
23 resid flows in from the bottom and out toward the edges of the vessel.

24

25 When the initial bore hole is complete, the drill bit is then mechanically  
26 switched to two (2) horizontal nozzles in preparation for cutting the "blow"  
27 hole, which extends to the full drum diameter. The nozzles shoot jets of water  
28 horizontally outwards, rotating slowly with the drill rod, and those jets cut the  
29 coke into pieces, which fall out the open bottom of the vessel, into a chute that  
30 directs the coke to a receiving area. At some plants the hydraulic drill is  
31 raised slowly up from the bottom the entire vertical height of the coke mass, at  
32 others the drill is lowered from the top through the mass and at still other  
33 plants the coke mass is first cut from the bottom cone of the vessel and the  
34 remainder is cut from the top of the vessel. In any case, the cut coke falls out

1 the opening at the bottom of the vessel into the coke chute system. The drill  
2 rod is then withdrawn out the flanged opening at the top of the vessel. Finally,  
3 the top and bottom of the vessel are closed by replacing the head units,  
4 flanges or other closure devices employed on the vessel unit. The vessel is  
5 then clean and ready for the next filling cycle with the heavy hydrocarbon  
6 feed.

7  
8 The process of removing and replacing the removable top head and bottom  
9 units of the vessel cover is called heading and unheading or deheading. It is  
10 dangerous work, with several risks associated with the procedures. There  
11 have been fatalities and many serious injuries. There is significant safety risk  
12 from exposure to steam, hot water, fires and repetitive stress associated with  
13 the manual unbolting work. Accordingly, the industry has devoted substantial  
14 time and investment in developing semi-automatic or fully automatic  
15 unheading systems, with attention focused on bottom unheading where the  
16 greatest safety hazard is present.

17  
18 There are two typical and commonly used methods to move the bottom head  
19 out of the way of the falling coke. The first is to completely remove the head  
20 from the vessel, perhaps carrying it away from the vessel on a cart. This  
21 process may be automated as set forth in U.S. Pat. No. 5,336,375. The other  
22 way of "removing" the bottom head is to swing it out of the way, as on a hinge  
23 or pivot, while the head is still coupled to the vessel as in U.S. Patent No.  
24 6,264,829. Several U.S. patents disclose various methods and apparatus for  
25 detaching and laterally moving a drum head or swinging away a drum head  
26 including: U.S. Pat. No. 6,264,829 (discloses a swing away hydraulically  
27 operated drumhead adapted for low headroom situations); U.S. Pat. No.  
28 6,254,733 (depicting in the drawings a hydraulically removable drumhead);  
29 U.S. Pat. No. 6,066,237 and 5,876,568 (disclosing an apparatus for semi-  
30 automatically clamping and unclamping a drum bottom head); U.S. Pat. No.  
31 5,947,674 (a drum head device removed by vertically oriented hydraulic  
32 cylinders adapted for lowering the head unit and moving it laterally aside);  
33 U.S. Pat. No. 5,785,843 (claims a process involving a swing away  
34 hydraulically operated drumhead adapted for low headroom situations); U.S.

1 Pat. No. 5,581,864 (a remotely operated carriage mounted drumhead removal  
2 system); U.S. Pat. No. 5,500,094 (car mounted drumhead removal system  
3 that is horizontally movable); U.S. Pat. No. 5,228,825 (a device and method  
4 for deheading a drum comprising, in part, a cradle that holds the drum head  
5 for removal); U.S. Pat. No. 5,221,019 (a remotely operated cart removal  
6 system); U.S. Pat. No. 5,098,524 (a pivotally attached unheading device  
7 associated with clamps); U.S. Pat. No. 4,726,109 (a platform device lowers  
8 the drumhead and moves it laterally away). These systems all use a manual  
9 or semi-automatic bolting system that must be uncoupled with every decoking  
10 cycle.

11  
12 The above described bottom head removal systems all require that the heated  
13 feed enter the coke vessel from the bottom through the center of the bottom  
14 head. Although in past years there have been some side entries used, except  
15 for possibly one or two cases, side entry use has been discontinued in coker  
16 vessels built and put into operation in the last 20 to 30 or more years. Thus,  
17 in the usual coker operation, to remove the vessel bottom head for decoking  
18 the feed line must first be disconnected before the bottom head can be  
19 removed. Lastly a coke chute must be manually or hydraulically moved into  
20 place and, typically, safety bolts are manually inserted to secure the chute to  
21 the drum, allowing the chute to receive the falling coke. The chute directs the  
22 coke, as it is drilled out of the vessel, to a receiving area where it is later  
23 removed. These methods still require the feed line to be opened up and the  
24 head removed before the bottom chute can be brought up and attached to the  
25 bottom flange of the vessel.

26  
27 Considering that there is exposure to personnel and/or equipment when  
28 opening the feed line, and considering there is exposure to personnel and/or  
29 equipment when opening the bottom head before the chute comes up and is  
30 attached, and considering there may still be personnel exposure to steam/hot  
31 water between the chute and bottom head after the chute is up, improvements  
32 in coke vessel bottom unheading system to allow safe removal of coke from  
33 the vessel is highly desirable. The object of the present invention is to  
34 address this need.

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2 SUMMARY OF THE INVENTION

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4 According to the present invention, a process and apparatus are provided for  
5 repetitively producing and removing coke from a delayed coker vessel without  
6 unheading the vessel bottom, wherein the coker vessel has a bottom portion  
7 having an aperture through which coke is released, comprising: (a) sealing an  
8 aperture closure housing to the bottom portion of the coker vessel; (b) moving  
9 a closure member within the closure housing to close the aperture; (c) feeding  
10 a heavy hydrocarbon feed into the coker vessel through a feed line attached  
11 to the coker vessel at a position above the bottom of the coker vessel; (d)  
12 coking the heavy hydrocarbon in the coker vessel; (e) moving the closure  
13 member within the closure housing to open the aperture to allow coke  
14 removal from the coker vessel; (f) releasing coke through the aperture into a  
15 coke chute, and; repeating steps c through f, successively. In a preferred  
16 embodiment of the invention the closure member is power actuated, such as  
17 hydraulically, by remote means, thus obviating any need for personnel to be  
18 physically present in the vessel bottom area during decoking operations.

19

20 The delayed coker vessel of the present invention comprises a vessel having  
21 a top opening and on the lower portion a side aperture and a bottom aperture;  
22 a feed pipe fitted to said side aperture; a bottom aperture closure housing  
23 sealed to the bottom aperture; a closure member moveable within said  
24 closure housing; a coke chute sealed to the bottom portion of the closure  
25 housing for directing material from the vessel to a receiving area. The  
26 combination of the closure housing and moveable closure member therein is  
27 herein termed a closure unit or valve. In one embodiment of the invention the  
28 bottom portion of the coker vessel is designed and fabricated to be directly  
29 sealed to the closure unit, whereas in another embodiment, particularly useful  
30 for retrofitting existing coker vessels, a bottom transition piece, herein termed  
31 a spool, is interposed between the vessel bottom and the closure unit and  
32 pressure-tightly sealed to both. In either of these two embodiments, a  
33 preferred feature is that the closure housing is pressure-tightly sealed to either  
34 (a) the coker vessel or (b) the spool piece. Preferably the pressure-tight seals

1 will withstand pressures within the range of about 100 psi to 200 psi,  
2 preferably within the range of about 125 psi to about 175 psi and most  
3 preferably between about 130 psi to about 160 psi and thereby preclude  
4 substantial leakage of the coker vessel contents including during operation  
5 thereof at temperature ranges between about 900°F and 1000°F. In  
6 embodiment (b) the spool preferably has a side aperture and flanged conduit  
7 to which the hydrocarbon feed line is attached and sealed.

8  
9 The present invention substantially reduces or eliminates the dangerous and  
10 time consuming procedure of heading and unheading delayed coker vessels,  
11 thus rendering the decoking procedure safer for personnel to perform by  
12 insulating them from exposure to tons of hot, falling coke, high pressure  
13 steam, scalding water, mobile heavy equipment and other extreme hazards.  
14 Among other factors, the present invention is based on our conception and  
15 finding that coke is safely and efficiently removed from a delayed coker vessel  
16 by the closed system process described herein, sometimes visualized by us  
17 as a "closed-pipe" system, which includes side entry for the feed to the vessel  
18 and a pressure-tight seal between a closure housing for a vessel bottom  
19 aperture. The vessel bottom aperture, which opens and closes, preferably  
20 includes automatic and remote operation of a closure unit, such as a valve,  
21 located at the bottom of the coker vessel rather than unbolting and removing  
22 or swinging away a "head" as in the prior art. One aspect of enabling the  
23 process of the present invention is introducing the heated hydrocarbon feed to  
24 the coker vessel at a location above and lateral to the coker vessel bottom  
25 and the closure unit, in combination with the above mentioned pressure-tight  
26 seals.

27  
28 A preferred embodiment of the present invention is additionally based on our  
29 finding that coke removal in the present process is advantageously carried out  
30 using a coke chute bolted and pressure-tightly sealed to the bottom of the  
31 closure housing. The chute, which preferably remains attached without  
32 removal throughout repetitive coking/decoking cycles, assists in directing coke  
33 removed from the coker vessel to a coke receiving area.

34

1 According to a preferred embodiment, the invention further relates to a  
2 method and apparatus for automatically opening and closing a vessel bottom  
3 aperture by means of a closure unit or valve, in lieu of the removable or  
4 partially removable head devices described in the prior art, and without the  
5 associated safety and efficiency drawbacks discussed above. In a preferred  
6 embodiment, which takes the place of the prior art removable closure flanges,  
7 spool pieces bolted to stationary vessel flanges, hinged flanges, carts,  
8 carriages and the like, powered devices, which may be controlled  
9 automatically, move closure a closure member within a closure housing  
10 between open and closed positions. These powered devices may comprise  
11 any powered actuators, including motors, solenoids, or the like, but preferably  
12 comprise linear actuators such as hydraulic or pneumatic cylinders with  
13 reciprocating piston rods. Such actuators may be mounted on the vessel the  
14 closure housing or other stationary location to reversibly and repetitively move  
15 the closure member from an open to closed position. Preferably the method  
16 of the invention does not typically require direct human intervention in  
17 proximity to the vessel bottom to actuate the powered devices, which is  
18 preferably accomplished by remote instrumentation means such as an  
19 electronic relay system or computer controlled system. The entire process is,  
20 thus, done safely and without significant or dangerous physical effort.

21

22 Although secondary to the significant safety improvements, the present  
23 invention also speeds up the procedure so that the coking/decking cycle time  
24 can be substantially reduced, without compromise in safety or human effort.  
25 The invention also renders the addition of this new closure device onto the  
26 hundreds of existing coker vessels to a relatively simple, quick, and  
27 inexpensive procedure, as compared to the difficult, expensive, and time  
28 consuming requirement of the existing methods and devices of the prior art  
29 described above.

30

### 31 BRIEF DESCRIPTION OF THE DRAWINGS

32

33 Figure 1 is a schematic diagram of the delayed coking process of the present  
34 invention. Figure 2 is a side view of a typical coke vessel bottom known in the

1 prior art depicting the typical bottom entry feed, removable vessel bottom  
2 head in one of the known arrangements and detachable coke chute  
3 arrangement in one of the known arrangements. Figure 3 is a side view  
4 depiction of a preferred embodiment of the present invention illustrating a  
5 coker vessel designed and fabricated to be directly attached and sealed to the  
6 closure housing and the side entry hydrocarbon feed line. Figure 4 is a side  
7 view depiction of another embodiment of the invention, particularly useful for  
8 retrofitting existing coker vessels, showing a spool or flange interposed  
9 between the coker vessel bottom and the closure housing. Figures 3 and 4  
10 additionally depict a coke chute affixed and sealed to the closure housing  
11 bottom. Figures 5 and 6 depict top and side views of the coke vessel closure  
12 unit with cut-a-way portions showing the movable closure member within the  
13 closure housing.

#### 14 DETAILED DESCRIPTION OF THE INVENTION

15  
16  
17 The invention relates to an improved method of repetitively coking heavy  
18 hydrocarbons in a coker vessel and repetitively decoking the vessel in a rapid,  
19 safe and efficient manner by simply opening and closing a closure member,  
20 such as a valve, within a closure unit, rather than removing or swinging away  
21 a bottom head unit, as in the prior art. As generally depicted in Figure 1,  
22 delayed coking is accomplished by charging hot, resid oil feed through a feed  
23 line **10** to the fractionator **15** above the bottom vapor zone **20**. Lighter  
24 hydrocarbon materials such as naphtha, gases, diesel and gas oils are taken  
25 from upper portions of the fractionator vessel **15** by appropriately placed  
26 conduits **25, 30, 35** and routed to other facilities for further refining.

27  
28 Fresh feed and recycled feed from the bottom of the fractionator **15** are  
29 pumped through a coker heater **40** where the combined feed is heated to a  
30 temperature ranging between about 900°F to 1000°F, preferably to between  
31 905°F to 950°F and most preferably to between 910°F and 935°F, partially  
32 vaporized and alternatively charged to one of a pair of coker vessels **45, 45a**  
33 via a feed line **50, 50a** laterally attached to the coker vessel **45, 45a**. Hot  
34 vapors from the top of the coker vessels **45, 45a** are recycled to the bottom of



1 the fractionator **15** via a feed line **55**. In this manner, the hot vapors from the  
2 coke vessel are quenched by the cooler feed liquid, thus preventing any  
3 significant amount of coke formation in the fractionator **15** and simultaneously  
4 condensing a portion of the heavy ends which are recycled to the coker  
5 vessels **45, 45a**. The unvaporized portion of the coker heater effluent settles  
6 out (coke) in the active coker vessel **45, 45a** where the combined effect of  
7 temperature and retention time results in coke formation. Coke formation in  
8 the coker vessel **45, 45a** is continued, typically between about 12 to about 30  
9 hours, until the active vessel **45, 45a** is full to within a safe margin from the  
10 vessel top.

11  
12 Once the active coke vessel **45, 45a** is full, the heated heavy hydrocarbon  
13 feed is redirected to the empty coker vessel **45, 45a** where the above  
14 described process is repeated. Coke is then removed from the full vessel by  
15 first quenching the hot coke with steam and water, then opening a closure unit  
16 **60** sealed to the vessel bottom, hydraulically drilling the coke from the top  
17 portion of the vessel and directing drilled coke from the vessel through the  
18 open closure unit into a coke chute **65** sealed to the bottom of the closure unit  
19 **60** to a coke receiving area **62**. Opening of the closure unit is safely  
20 accomplished by a remotely located control unit **70**.

21  
22 Key features of the coking method and coker vessel of this invention include  
23 the side entry feed line **50a** and **50b** (see Figures 3 & 4), the closure unit **60**,  
24 with a moveable closure member therein, pressure-tightly sealed to the vessel  
25 bottom **45, 45a** and a coke chute **65** pressure-tightly sealed to the bottom of  
26 the closure unit **60**. The side entry feed line **50b** can be attached to the  
27 vessel side from about 6 inches to about 5 feet above the vessel bottom,  
28 preferably from 1 foot to about four 4 feet from the vessel bottom and most  
29 preferably from 1.5 feet to 2.5 feet from the vessel bottom.

30  
31 Referring to Figures 3 and 4, said pressure-tight seals are accomplished in  
32 one preferred embodiment (Figure 3) preferably by means of a gasket **90**  
33 interposed between facing flanged surfaces of the coke vessel bottom **75**, the  
34 closure unit **75a** and the coke chute **75b** and the closure unit **75c**. In another

1 preferred embodiment (Figure 4), a spool piece **80** is used to adapt coke  
2 vessel bottom apertures and closure unit **60** apertures of different diameters.  
3 In this embodiment said pressure-tight seals are preferably accomplished  
4 between facing flanged surfaces of the coke vessel bottom **75**, the spool  
5 piece **85**, the closure housing **75a**, the spool piece **85a** and the coke chute  
6 **75b** and the closure unit **75c**. To form the pressure tight seals between said  
7 flanged surfaces preferably the mating surfaces of the respective flanges are  
8 machined to a desired finish, then pressure-tightly joined together with a  
9 plurality of suitable fasteners, such as bolts, clamps or similar means and with  
10 a carefully selected gasket **90** interposed between said mating surfaces.  
11 Similarly, to form the pressure tight seals between the flanged surfaces of the  
12 closure housing bottom **75c** and the coke chute **75b** preferably the mating  
13 surfaces of the respective flanges are machined to a desired finish, then  
14 pressure-tightly joined together with a plurality of suitable fasteners, such as  
15 bolts, clamps or similar means and with a carefully selected gasket **90**  
16 interposed between said mating surfaces. The method for sealing the coke  
17 chute **65** to the closure unit bottom may be different from the method for  
18 sealing the vessel or spool to the closure unit top because operating  
19 conditions are not a critical factor for seal integrity.

20  
21 According to a more detailed embodiment, preferably, said flanged surfaces  
22 are first machined to an RMS (root mean squared) finish ranging from 50 to  
23 400, preferably 100 to 300 and most preferably between about 120 to 130.  
24 An annular gasket comprised of a metal core, such as stainless steal, and a  
25 flexible material suitable for use as a gasket in combination with metal under  
26 temperatures ranging from -50°F to 1000°F and pressures ranging from 100  
27 psi to 200 psi is fitted to one of the flanged surfaces of each of the coke  
28 vessel bottom **75**, the spool piece **85**, **85a** and the closure housing **75a**. With  
29 the gasket interposed between each, the coke vessel bottom **45**, and the  
30 closure housing **60** (and in another embodiment the spool piece **80**) are  
31 pressure-tightly joined together by a plurality of suitable fasteners, such as  
32 bolts, clamps or similar means. The fastening means, such as bolts, clamps  
33 or similar means are tightened or torqued such that the pressure placed on

the gaskets **90** ranges between 10,000 PSI to 30,000 PSI, preferably between 15,000 and 25,000 PSI and most preferably 20,000 PSI. Preferably, said torque pressure is applied evenly around the gasket circumference.

In a preferred embodiment of the present invention the metal gasket is annular and stainless steel ranging in thickness from about .020 " to .140', preferably about .024" to about .035" and most preferably from about .028" to about .032", and is concentrically corrugated. Said corrugations range in height above the metal surface of the gasket from a minimum of about 0.001 inches to a maximum of about 0.050 inches, preferably from a minimum of about 0.005 inches to a maximum of about 0.030 inches and most preferably from a minimum of about 0.010 inches to a maximum of about 0.020 inches. Once corrugated, the width of the gasket is such that the outside and inside diameters thereof are respectively coincident with the outside and inside diameter of the flanged surfaces of the coke vessel bottom, the spool piece, the closure unit and the coke chute. Flexible graphite material, such as Polycarbon flexible graphite Grade B or BP (with antioxidant inhibitor) or Union Carbide flexible graphite grade GTB or GTK (with antioxidant inhibitor), is bonded to the upper and lower surfaces of the gasket metal core such that the gasket is sandwiched between the layers of graphite material. Thickness of the graphite material can range from about 0.005 inches to about 0.030 inches, preferably between 0.010 inches to about 0.025 inches and most preferably is about 0.015 inches thick. Preferably the graphite covering will have the same nominal inside and outside diameter dimensions of the metal gasket. Upon bonding to the gasket metal core surfaces, the corrugations thereof should be covered by the graphite material. Sealing the flanged surfaces of the coker vessel, the spool piece, the closure unit and, optionally, the coke chute in the manner described above results in a pressure-tight seal that tolerates the differential expansion that occurs between the flanges during the repetitive coking/decoking cycles of the present invention.

Figures 3 and 4 depict preferred embodiments of the coker vessel. Figure 3 depicts the lower portion of a coker vessel **45** which can be 15 to 30 feet in diameter and 80 to 100 feet tall, which is typically cone or funnel shaped on

1 the lower end and which is attached to a lower flange **75** that is typically 60 to  
 2 72 inches in diameter. A closure unit **60** is pressure-tightly attached or sealed  
 3 to the lower flange **75**. The closure unit **60** has a flanged lower portion **75c**,  
 4 which is pressure-tightly attached or sealed to a coke chute **65**. The closure  
 5 unit **60** and coke chute **65** remain sealed in place during repetitive coking and  
 6 decoking cycles, but can be detached and laterally moved away from the  
 7 vessel **45** for maintenance via a gantry system, trolley system, rail mounted  
 8 cart or carriage or other similar system. The number of coking cycle  
 9 repetitions that can be carried out prior to breakdown of the system for major  
 10 maintenance can vary from 10 to 150 cycles, preferably 20 to 100 cycles and,  
 11 most preferably, from 30 to 75 cycles per pair of vessels.

12

13 Figure 4 depicts another embodiment of the invention that is particularly  
 14 suitable for retrofitting existing coker vessels. As in the first embodiment the  
 15 coke vessel **45** is typically cone or funnel shaped on the lower end which is  
 16 attached to a lower flange unit **75** that is typically 48 to 72 inches in diameter,  
 17 preferably 60 to 72 inches in diameter. Interposed between the lower flange  
 18 **75** and the closure housing **60** is a spool piece **80** having a flanged top **85** and  
 19 bottom **85a** and a laterally attached flanged conduit **50b** for attachment to the  
 20 heavy hydrocarbon feed line **50a**. The spool piece **80**, in one embodiment,  
 21 can be of equal diameter on the top and bottom or, in another embodiment,  
 22 conical in shape to adapt the coker vessel opening diameter to the closure  
 23 unit opening diameter, for example a vessel opening of about 72 inches and a  
 24 closure unit opening of about 60 inches in diameter.

25

26 Figures 5 and 6 respectively depict plan and side cut-away views of the  
 27 closure unit of a preferred embodiment of this invention. The closure unit **60**  
 28 of this invention is a slide, gate, knife, ball, wedge plug or similar type valve  
 29 comprising a closure housing **115** defining an interior void wherein a closure  
 30 member **120** is mounted to an actuator or actuators **125**, such as hydraulic  
 31 pistons **130** such that said closure member can be laterally moved to an open  
 32 or closed position. The closure housing further comprises a first end section  
 33 **135**, a second end section **140** and a middle section **145** which middle section  
 34 defines an aperture **150** that can range in size from 48 to 72 inches in

1 diameter. When moved laterally within the closure housing **115** the closure  
2 member **120** opens and closes said aperture **150**.

3  
4 To begin the coking cycle described above the closure member **120** is moved  
5 laterally to close the vessel bottom by operating the actuators **125**, such as  
6 hydraulic cylinders **130** that are, preferably, automatically and remotely  
7 operable. When the closure member is moved into the fully closed position  
8 the closure housing **115** is purged with nitrogen and/or steam via inlet valves  
9 **155** mounted in the closure housing body **115**. Coking then begins by the  
10 process described above. During the coking phase of the coking cycle block  
11 pressure steam is injected into the closure housing body at a rate sufficient to  
12 maintain pressure at a level to effectively eliminate hydrocarbon leaks at the  
13 closure member/closure housing seat **160**. Blocking steam pressure and flow  
14 rate are continuously monitored during the coking phase by use of pressure  
15 and flow rate measuring devices **165** installed in the closure housing **115** and  
16 connected to a remotely located control unit **70**.

#### 17 18 EXAMPLE

19  
20 In a coking vessel used for delayed coking of heavy petroleum hydrocarbon  
21 feed stocks, after about 24 hours of operation sufficient coke is accumulated  
22 in the vessel such that removal of the coke is required before coking  
23 operations can continue in the vessel. At this point the heated heavy  
24 hydrocarbon feed is redirected to an adjoining empty coke vessel. The full  
25 coke vessel which is equipped with a lower spool transition piece, a closure  
26 unit and attached coke chute operated in accordance with a preferred  
27 embodiment of this invention, is shut down, quenched, depressurized and the  
28 closure member within the closure housing unit is hydraulically moved  
29 laterally to open the coke vessel bottom. Hydraulic movement of the closure  
30 member is actuated by workers from a safe, remotely located control system.  
31 Important characteristics of the coker vessel used in preferred embodiments  
32 of the present invention that can be repetitively cycled through the coking and  
33 decoking process without removing the closure unit and coke chute, include:  
34 A coker lower flange equal to 72 inches in diameter; a flanged spool transition

1 piece wherein the top flange of the spool piece is 72 inches in diameter and  
 2 the bottom flange is 60 inches in diameter; a hydrocarbon feed inlet line  
 3 installed laterally on the spool piece; a closure housing with a 60 inch  
 4 diameter opening therein; a closure member laterally moveable by hydraulic  
 5 means within the closure housing; a coke chute 60 inches in diameter  
 6 attached to the bottom opening of the closure housing; and a 60 inch stroke  
 7 closure member hydraulic actuator powered by a 3000 psi pump.

8

9 Referring again to the coking process steps, upon redirection of the  
 10 hydrocarbon feed from the full coker vessel to the empty coker vessel, 4000  
 11 pounds per hour of steam at 150 psi is injected into the full vessel via the  
 12 laterally installed inlet line. The steam strips uncoked hydrocarbon from the  
 13 vessel which is routed to the fractionator. After a period of time, usually about  
 14 two hours, the vessel is isolated from the fractionator and depressurized  
 15 through a relief system. Stripping steam is thereafter continued for an  
 16 additional hour and thereafter quench water is added to the vessel at a slow  
 17 rate to cool the coke bed to approximately 200°F. Upon cooling the vessel to  
 18 the desired temperature the water is drained from the vessel via the inlet line  
 19 or by, partially or fully, opening the closure member in the closure housing to  
 20 drain water from the vessel into the coke receiving area.

21

22 Once the coke bed is cooled and the water drained, the vessel is prepared for  
 23 drilling coke from the vessel with the hydraulic drill system. The closure  
 24 member within the closure housing is opened hydraulically by remote  
 25 actuation thereby allowing the drilled coke to fall into the coke chute which is  
 26 attached to the bottom of the closure housing. As the coke is drilled it falls out  
 27 of the vessel into the coke chute and is directed into the coke pit. Upon  
 28 completion of the drilling process the hydraulic drill stem is removed from the  
 29 top of the vessel, the vessel top head is replaced and the inlet line and coke  
 30 vessel are visually inspected for plugging. Once the inspection is complete  
 31 and the removal of coke and absence of plugging is verified, the closure  
 32 member within the closure housing is hydraulically closed. Then steam is  
 33 injected into the vessel to purge air and pressure the vessel to test the  
 34 integrity of the top head seals, inlet line seals, closure housing/vessel/spool

1 seals, and the closure member seals within the closure housing. Finally, the  
2 vessel is preheated to about 400°F to 600°F skin temperature. When the  
3 desired temperature is reached the resid hydrocarbon feed is switched into  
4 this vessel and the adjoining vessel is prepared for decoking in accordance  
5 with the above process.

6  
7 Thus, according to a preferred embodiment of the present invention, a  
8 delayed coking method and coke vessel have been provided which allow the  
9 automatic, safe, quick, and effective opening and closure of coke vessels, or  
10 the like. While the invention has been herein shown and described in what is  
11 presently conceived to be the most practical and preferred embodiment  
12 thereof, many other modifications may be made within the scope of the  
13 invention, which scope is to be accorded the broadest interpretation of the  
14 appended claims so as to encompass all equivalent structures and methods.  
15 For example, the structures of the invention may be reduced in size by a  
16 factor of two, thus making it about 36 inches in nominal size, inverted, and  
17 applied in like form but smaller, to provide the highly desired automation of the  
18 flanged closure on the top of the vessel.